SYSTEM FOR U-2R

D. R. NAVIGATION SYSTEM

The Dead Reckoning Navigation System combines a modified AN/APN-153(V) Doppler Navigation System with a modified AN/ASN-66 Dead Reckoning Navigation Computer System. The Doppler system supplies aircraft drift angle and ground speed information to the Navigation Computer in addition to displaying both functions on the Doppler control panel. Utilizing the Doppler signals and aircraft magnetic heading, the Navigation Computer constantly computes and displays present position in Latitude and Longitude, and computes and displays steering information and distance to go to a selected target or destination from the present position of the aircraft. Between the 72° latitudes, steering and distance information is based on a great circle course until the range reaches 200 N. M. and then automatically switches to (STRAIGHT) Rhumb line computations. At latitudes greater than 72°, great circle computations are used regardless of the distance to go. The Navigation Computer will accept three separate predetermined targets at one time and is designed so that through leap frog techniques an unlimited number of targets are available during flight. The Navigation Computer also utilizes the Doppler signals in combination with a synthetic (canned) true air speed signal (locked rotor synchro adjusted to supply a constant TAS value of 392 knots) to compute and display the true wind magnitude and direction.

Steering information and distance to go are presented on the BDHI; relative ground track on Pointer No. 1; relative bearing to the selected target on

Pointer No. 2; distance to go, up to 1999 nautical miles.

Pointer No. 1, ground track, depicts the affect of aircraft drift; for example, if there is zero wind the pointer will be directly in line with the BDHI lubber line. If there is a wind vector from the port side which causes the aircraft to drift to the right of the desired ground track, the pointer will be displaced to the right of the lubber line. The amound of drift is determinable by reading the number of degrees, on the compass card, between the lubber line and the pointer. This same drift value will be displayed on the Doppler control panel. In order to establish the original flight line ground track, it would be necessary to turn left until the No. 1 pointer was pointing to the magnetic heading of the desired ground track. If the wind vector remained constant the aircraft would fly along the desired ground track with a crab angle which was equal to the drift angle.

Pointer No. 2, relative target bearing, always points to the great circle magnetic heading to the target except for the last 200 N.M. as described in the first paragraph. If the target is directly ahead of the aircraft, the pointer will be directly under the lubber line of the BDHI. If the target is 90° to port of the flight path, the pointer will be displaced 90° CCW from the lubber line. The No. 2 pointer functions exactly the same as when utilized as a VOR pointer, the only difference being that the navigation computer generates a hypothetical VOR station located in space.

To steer the aircraft to the target selected, change the ground track of the aircraft until the ground track heading coincides with the target bearing (i.e., fly the No. 1 pointer to the No. 2 pointer until they coincide or are aligned even if the alignment occurs at a relative heading other than directly under the lubber line. Under the latter condition, the difference in heading between the aligned pointers and the lubber line represents aircraft drift angle).

Since the BDHI pointers are being used for a dual purpose; (1) ADF & VOR Relative Bearings, and (2) Navigation Steering Signals, a transfer switch has been provided to enable the pilot to utilize the Radio Navigation aids without disrupting the D.R. Navigation System computations. This switch is located on the right-hand console trim panel just outboard of the AFCS controller. When "ADF/VOR" is selected, normal Radio Navigation technique are available. The D.R. Navigation computer continues to compute all functions; however, the steering information will not be displayed on the BDHI until the transfer switch is placed in the "ASN-66" position. The VOR Course Indicator, (localizer - glide slope - VOR steering) is not affected by the D.R. Navigation system. The distance to go counters will function normally and will display miles to go regardless of the position of the transfer switch during D. R. Navigation operation.

Doppler will on occasion enter the "Memory" mode of operation. This generally occurs during bank angles in excess of 12 degrees, or over water which has a

smooth sea state. The Memory mode is indicated by a "Memory" light located on the Doppler control panel, and when illuminated, signifies that the drift and ground speed signal are locked on the values shown on the Doppler control panel. In addition, the wind computations displayed on the Nav controller, are locked to the values shown. Memory occurs because the radar signal strikes a terrain so smooth that the signal is not reflected back to the receiver located in the aircraft. The Doppler will continue to transmit and will go off of Memory when the terrain or sea state provides that surface roughness required to return the radar signal to the aircraft. Many equipment malfunctions will also result in a Memory indication.

Should it be apparent that the Doppler has failed, as evidenced by a continuous Memory light, the wind information will normally be inserted manually. True wind direction and speed forecasts are shown on the maps provided to the pilot.

Arrival at the selected target is denoted by a zero "miles to go" BDHI reading, and by the present position counters reading the same as the target counters. Should the aircraft fly overand past the target, the No. 2 BDHI target bearing pointer will swing 180° and point in the opposite direction from the ground track (behind the aircraft). The target bearing presented on the BDHI will always point to the selected target; for example, if during a perfect circular orbit around the target, the No. 2 target bearing pointer will be positioned 90° abeam

of the aircraft, and the distance to go will remain fixed during the orbit.

The Navigation Power switch, located on the right-hand console trim strip, just outboard of the AFCS controller, energizes the No. 2 inverter and supplies power to the Navigation system. The power system has been designed with a priority circuit such that the Navigation System will be automatically shut off if:

1. The normal inverter selector switch is positioned to INVERTER NO. 2, or:
2. During normal operation the AC Generator fails, causing automatic transfer of System 13 to the NO. 2 INVERTER.

CONTROLS

The APN-153(V) Doppler control panel contains the following: rotary function switch with five positions - OFF, STBY, LAND, SEA, and TEST; a drift angle slewing knob; a ground speed slewing knob; a memory light; and an indicator which displays drift angle and ground speed.

The "TEST" position is a self test feature which indicates proper Doppler operation by slewing the control panel readings to $0 \pm 2^{\circ}$ drift and 121 ± 5 knots ground speed. The "STBY" position is used prior to takeoff. The "LAND" position is used when flying over land terrain and is switched to "SEA" when flying over water. The drift angle and ground speed slewing knobs will not be used during flight because

of other provisions contained in the ASN-66.

The ASN-66 navigation control panel contains the following: a six position rotary function switch - TEST, OFF, STBY, TGT 1, TGT 2 and BASE; destination (DEST) switch - (TGT 1 and TGT 2); variation counter with slewing knob; target latitude and longitude counters with slewing knobs; present position latitude and longitude counters with slewing knobs; wind-from counter with slewing knob; and wind-knots counter with slewing knob.

The "TEST" position is a self test feature which indicates proper Navigation computer operation by slewing the wind counters to readings of $240 \pm 1.4^{\circ}$ TRUE and 167 ± 5 KNOTS. The "VARIATION" counter must be set to 0° during self test.

The home base or desired landing site coordinates are inserted in the computer memory with the function switch placed on "BASE". The coordinates of the first two targets on the flight plan are inserted into the computer memory by positioning the function switch to "TGT 1" and "TGT 2" respectively; henceforth, the target counters will display the previously inserted coordinates whenever selected or until new coordinates are inserted.

The function switch, when positioned in either "TGT 1" or "TGT 2", has no effect on the Navigation steering computation. This function provides the pilot with a target recall capability for the purpose of rechecking previously inserted target

coordinates, or for the insertion of new target coordinates in the unused channel, without disturbing the Navigation computations or steering information being provided through the "DEST" switch. The position of the "DEST" switch, "TGT 1" or "TGT 2", determines to which target Navigation computations and steering information is provided. The "DEST" switch can be alternately switch to either position and, after a very short wait period, steering information will be presented on the BDHI. The "DEST" switch in no way effects the memory logic of any of the target memory channels; however, when the function switch is on "BASE", the computer navigates to, and displays the steering information to the Base site regardless of the position of the "DEST" switch. If desired, the function switch can be returned from "BASE" to either "TGT 1" or "TGT 2" and normal navigation techniques to the previously inserted targets can be resumed. To preclude accidental selection of the "BASE" position, a "press-to-rotate" bar has been built into the function switch knob.

Normally "TGT 1" and "TGT 2" will be alternately selected by the "DEST" switch and while flying to that destination a new set of target coordinates will be inserted in the unused channel as defined by the position of the function switch. This allows "leap frog" capabilities for insertion of new target coordinates during flight without disturbing the existing steering computations.

OPERATION

Accomplish items 1 through 19 before takeoff.

1. Turn NAV PWR switch ON.

2. Position NAV PTR TRANSF switch to ASN-66.

3. Turn the ASN-66 and DOPPLER function switches from OFF to TEST for a 2 minute warmup. (5 min. for Doppler.)

4. Set ASN-66 VARIATION to 0°. Allow ASN-66 wind counters and the Doppler drift and ground speed counters to stop. Proper test readings are as follows:

DRIFT:	$0 \pm 2^{\circ}$
GND SPEED	111 to 126 Knots
MEMORY LIGHT	OFF

ASN-66:

WIND DIRECTION	238.5° to 241.5°
WIND VELOCITY	162 to 172 Knots

Present position counters will move Northerly and Easterly.

5. Turn both function switches to STBY.

6. Set in correct Magnetic Variation.

7. Set in approximate Wind Direction and Velocity.

8. Turn function switch to BASE and pull switch out.

9. Set in desired landing site Latitude and Longitude on TARGET counters.

10. Push in function switch. Allow WAIT light to go out and confirm TARGET readings.

11. Turn function switch to TGT 2 and pull switch out.

12. Set in TGT 2 Latitude and Longitude on TARGET counters.

13. Push in function switch. Allow WAIT light to go out and confirm TARGET readings.

14. Turn function switch to TGT 1 and pull switch out.

15. Set in TGT 1 Latitude and Longitude on TARGET counters.

16. Push in function switch. Allow WAIT light to go out and confirm TARGET readings.

17. Turn function switch to STBY.

18. Set in Latitude and Longitude of Starting Point on POSITION counters.

19. Switch DEST. switch to TGT 1 position.

NOTE:

a) Destination (DEST.) switch position determines selection of target steering information delivered to the BDHI.

b) Function switch in normal position displays stored target coordinates. Function switch in out detent position permits insertion of new target coordinates.

c) The Function switch incorporates a detent feature to prevent accidental switching to OFF or SELF-TEST and has a "PRESS TO ROTATE" bar to prevent accidental switching to BASE.

JUST PRIOR TO TAKE OFF ROLL:

20. Turn Doppler function switch to LAND.

JUST AFTER GEAR UP:

21. Turn ASN-66 function switch to TGT 1.

22. Steer Pointer No. 1 to Pointer No. 2 and align No. 1 over No. 2 to steer aircraft to target No. 1.

23. At zero miles to go and at Latitude and Longitude over TGT 1, switch DEST switch to TGT 2 and steer to TGT 2. Adjust VARIATION as necessary.

24. With function switch in TGT 1 position pull switch out. Manually insert TGT 3 coordinates. Push in function switch and allow WAIT light to go out. Turn function switch to TGT 2 for display of TGT 2 coordinates.

25. At zero miles to go and at Latitude and Longitude over TGT 2, switch DEST. switch to TGT 1 and steer to TGT 3. Adjust VARIATION as necessary.

26. With function switch in TGT 2 position pull switch out. Manually insert TGT 4 coordinates. Push in function switch and allow WAIT light to go out. Turn function switch to TGT 1 for display of TGT 3 coordinates.

27. For additional targets, repeat steps 23 through 26 with appropriate changes in Latitude and Longitude coordinates and Variation.

NOTE: If check points can be visually ascertained along a flight path and if accurate coordinates are known, Present Position updating can be performed as follows:

a) When check point is unmistakeable, determine if Present Position correction is necessary.

b) If necessary, place function switch to STBY.

c) Set in check point coordinates on Present Position counters and overfly the check point.

d) When directly over check point, place function switch to appropriate target position.

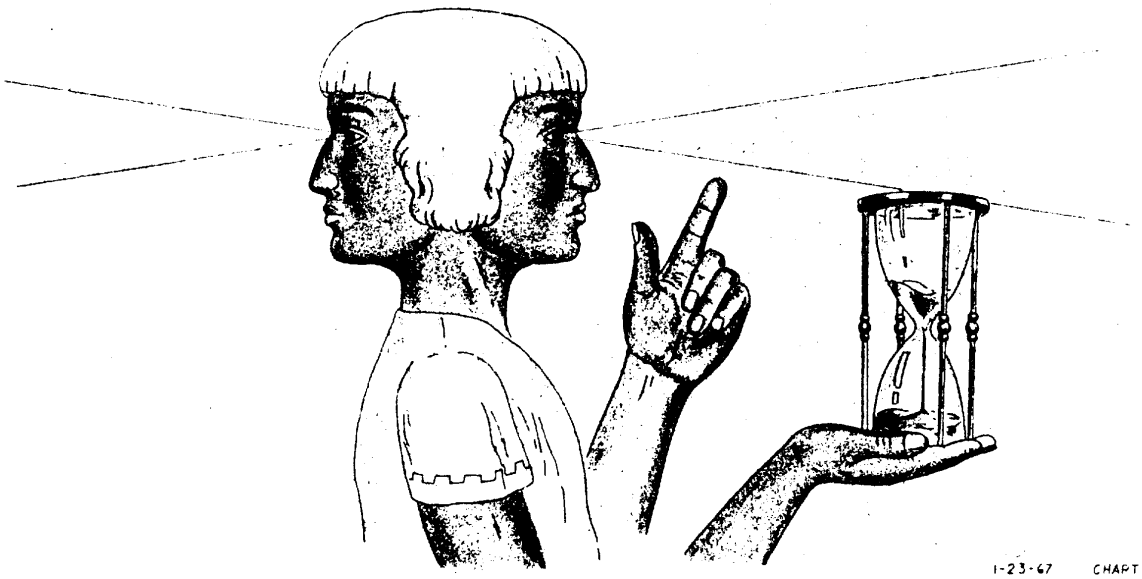
Occasionally monitor the Doppler control panel memory light. If illuminated for more than 3 to 4 minutes, manually insert wind magnitude and direction from map weather data. Select DOPPLER OFF and then test position to check operation of the Doppler System. If system should not test correctly, the system should be turned off.

Should the flight plan cross water, select the SEA mode on the Doppler control panel for that period of flight over water. Return to the LAND mode when back over land terrain.

DEAD RECKONING NAVIGATION SYS.

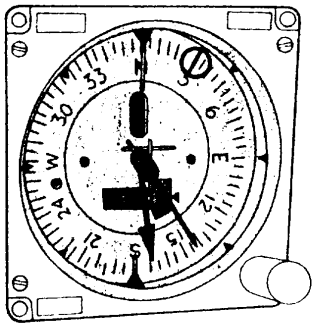
ASN-66 C NAV

APN-153(V) MOD DOPPLER

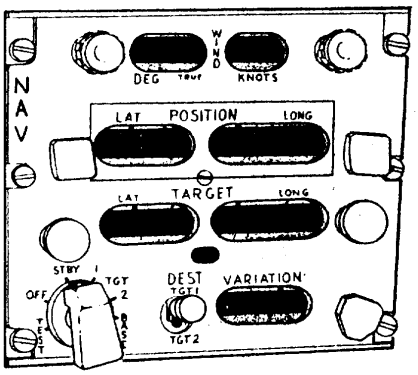


1-23-67 CHART PROGRAM NO 672

PILOTS NAVIGATION EQUIPMENT



BDHI



NAV CONTROLLER

NAV POINTER TRANSFER ASN - 66

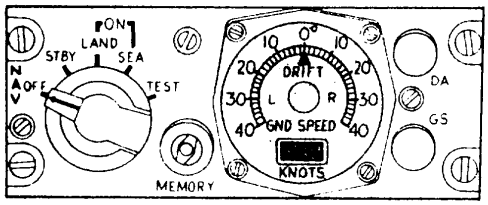
ADF/VOR

NAV POWER NO.2 INV

OFF

COMPASS POWER AIRCRAFT

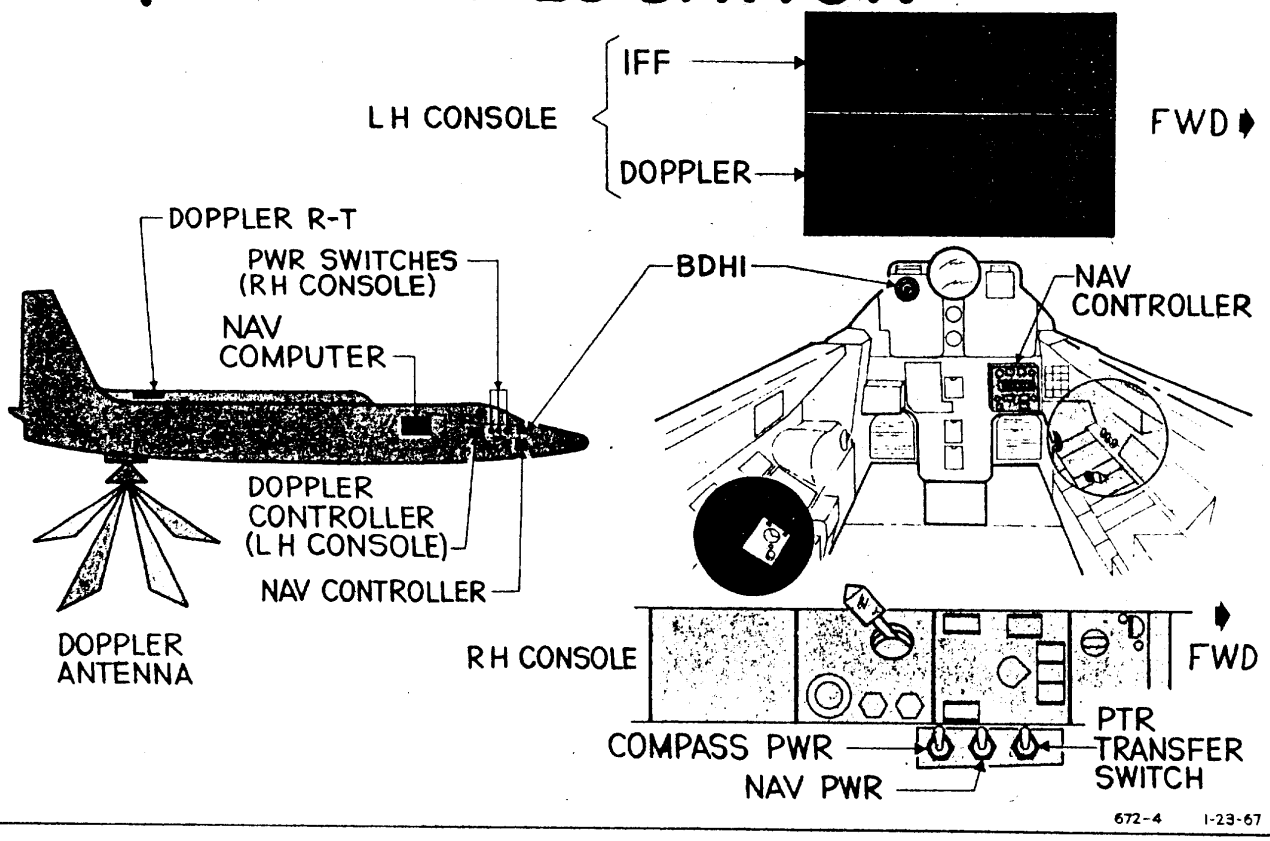
EXTERNAL

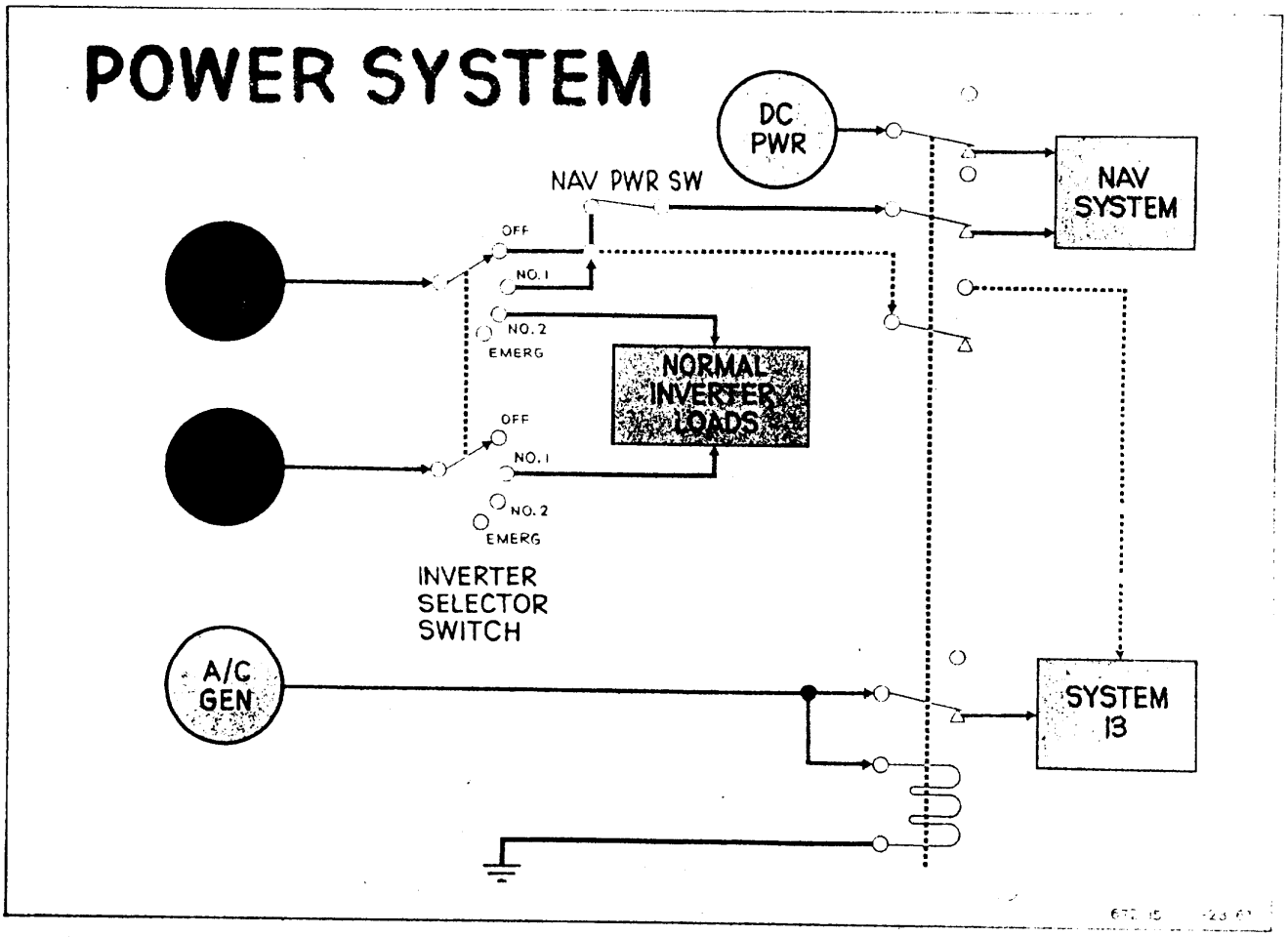


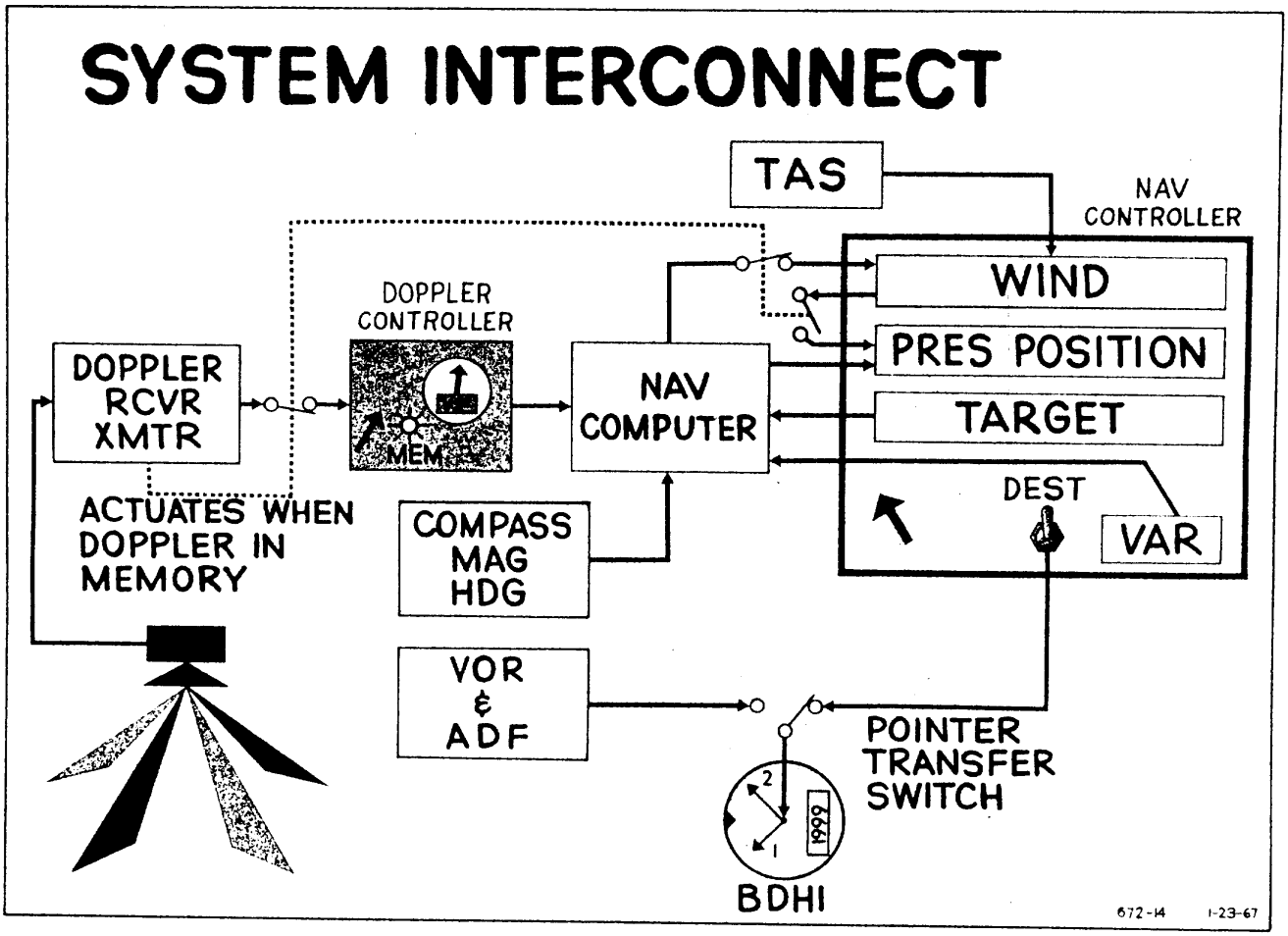
DOPPLER CONTROLLER

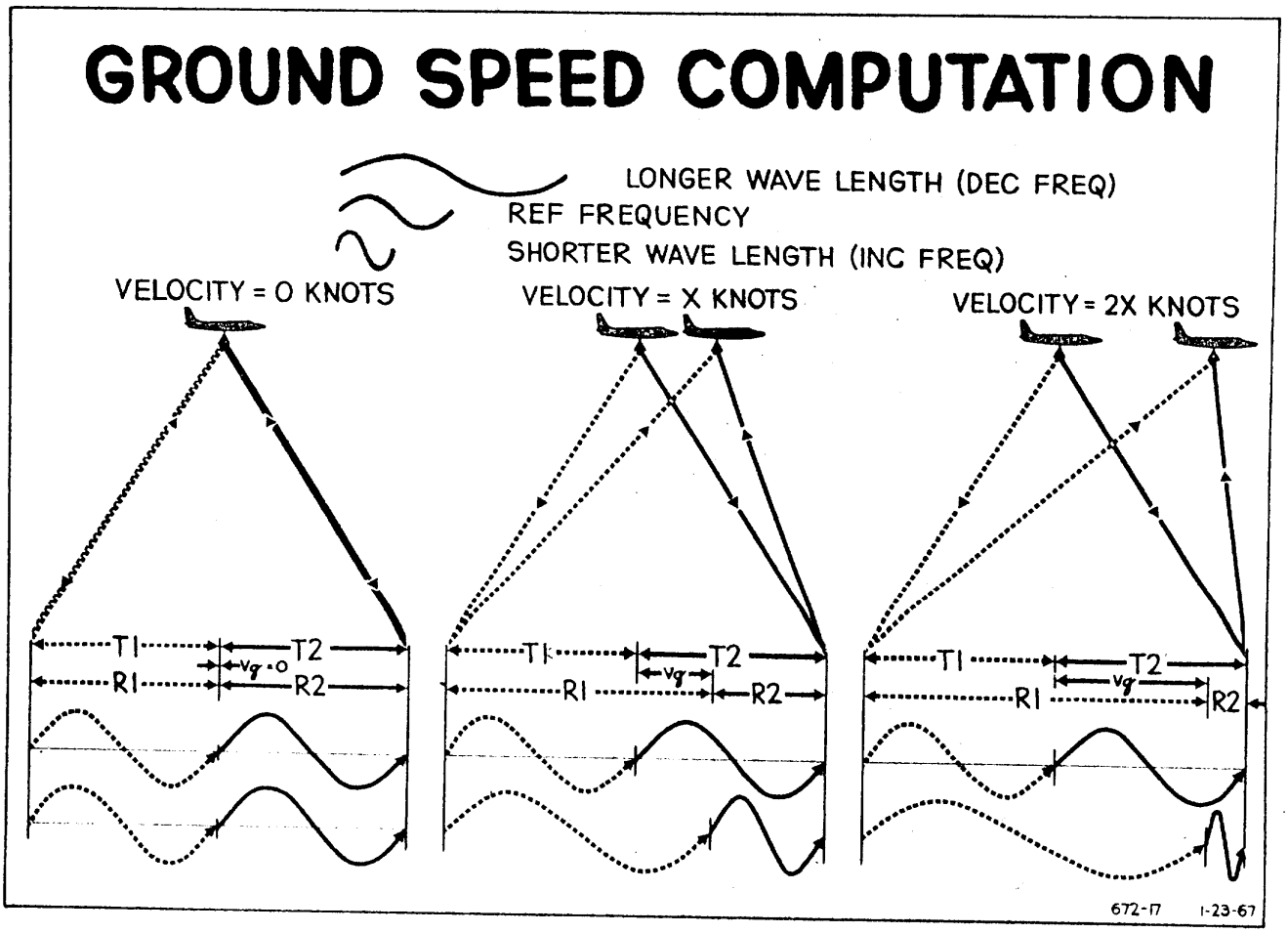
672-1 1-23-67

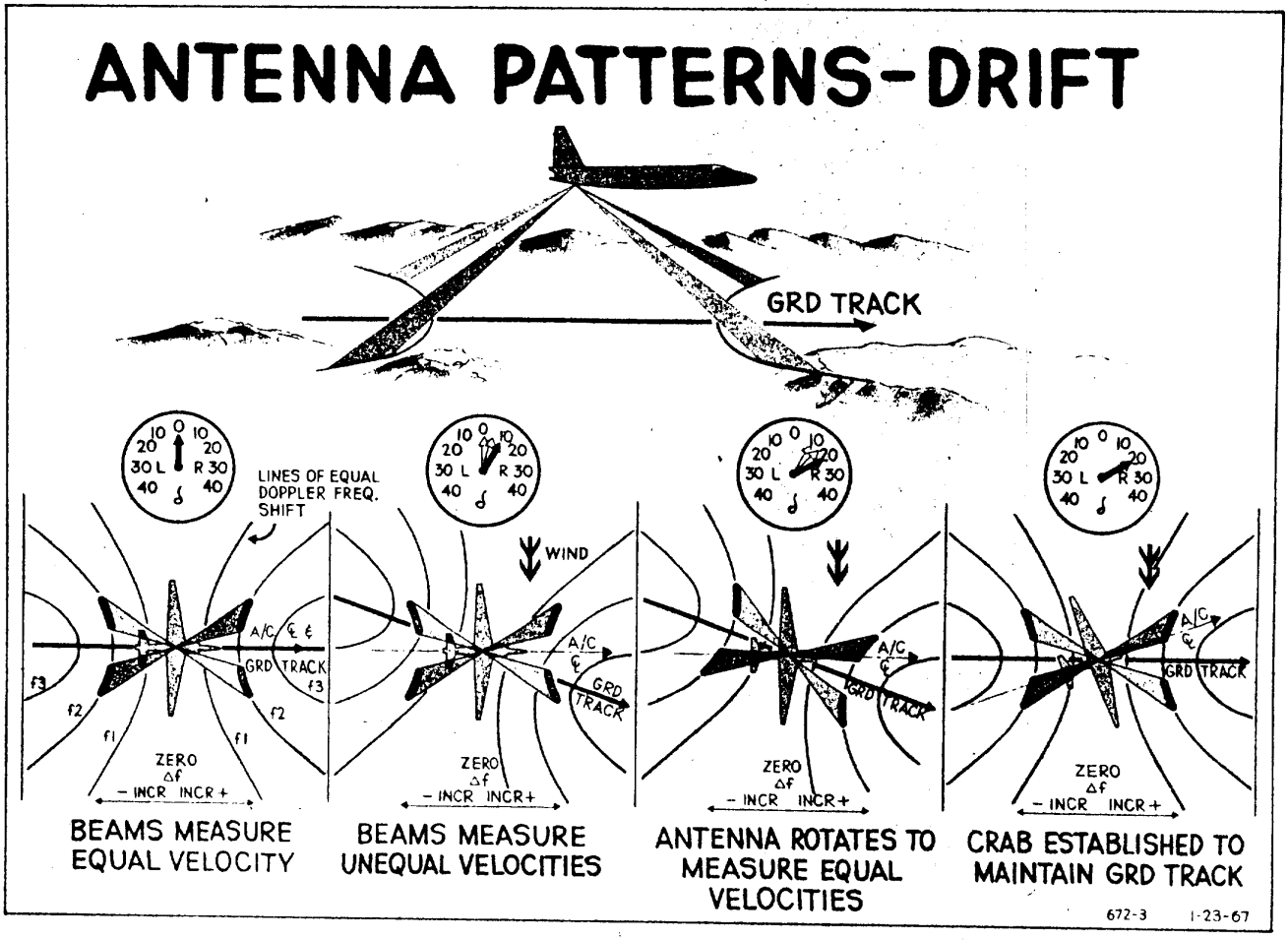
EQUIPMENT LOCATION

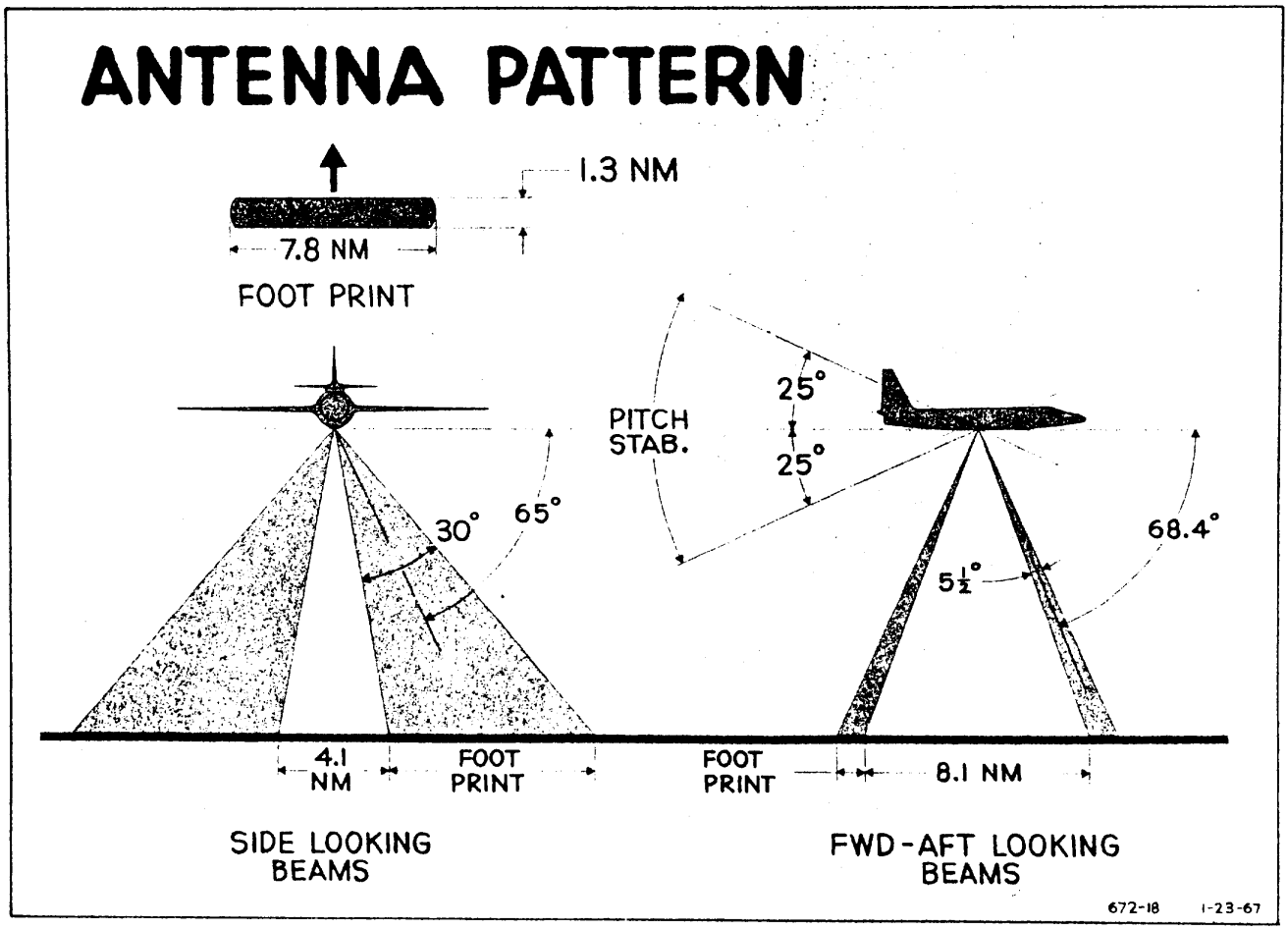


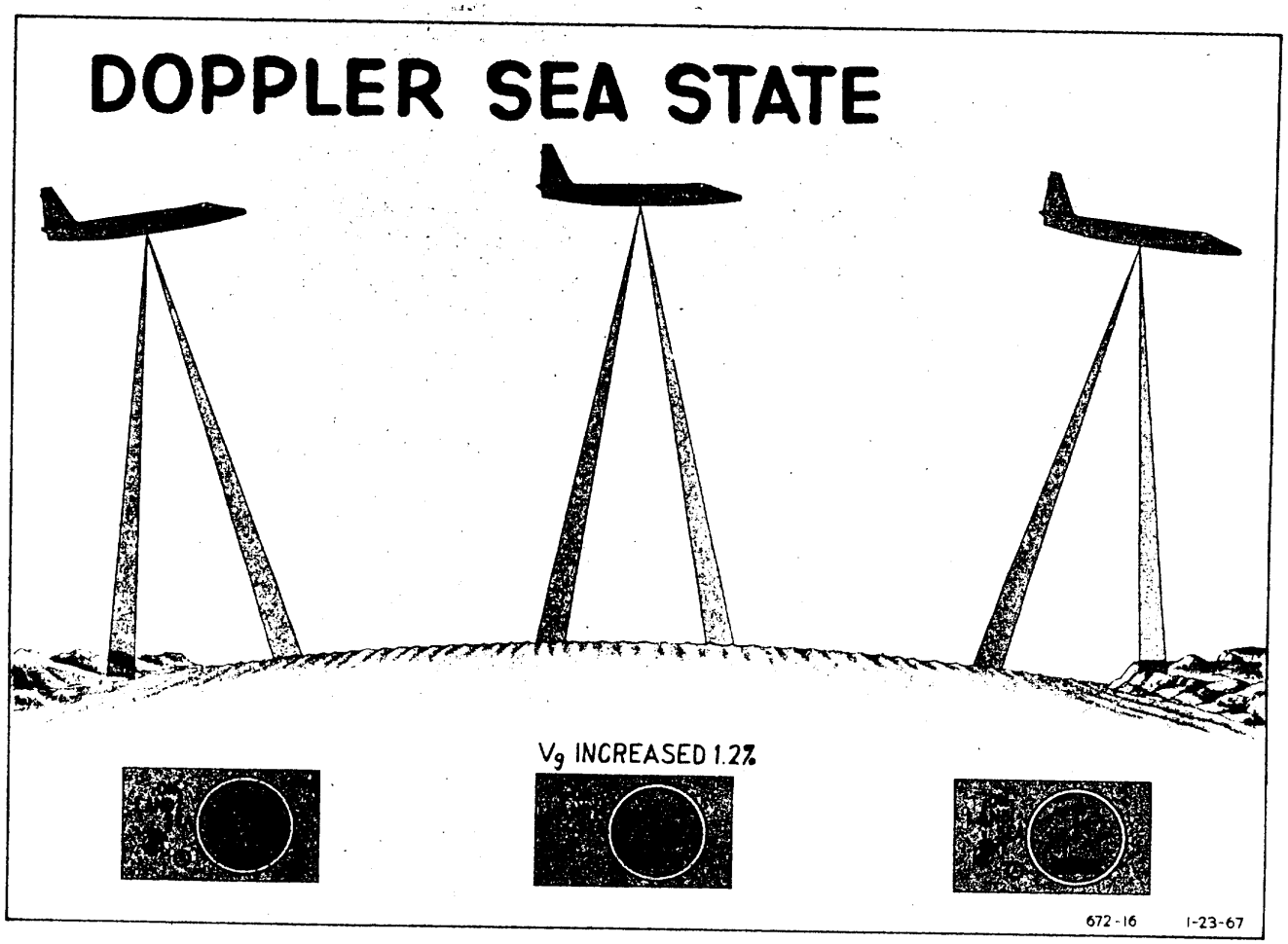




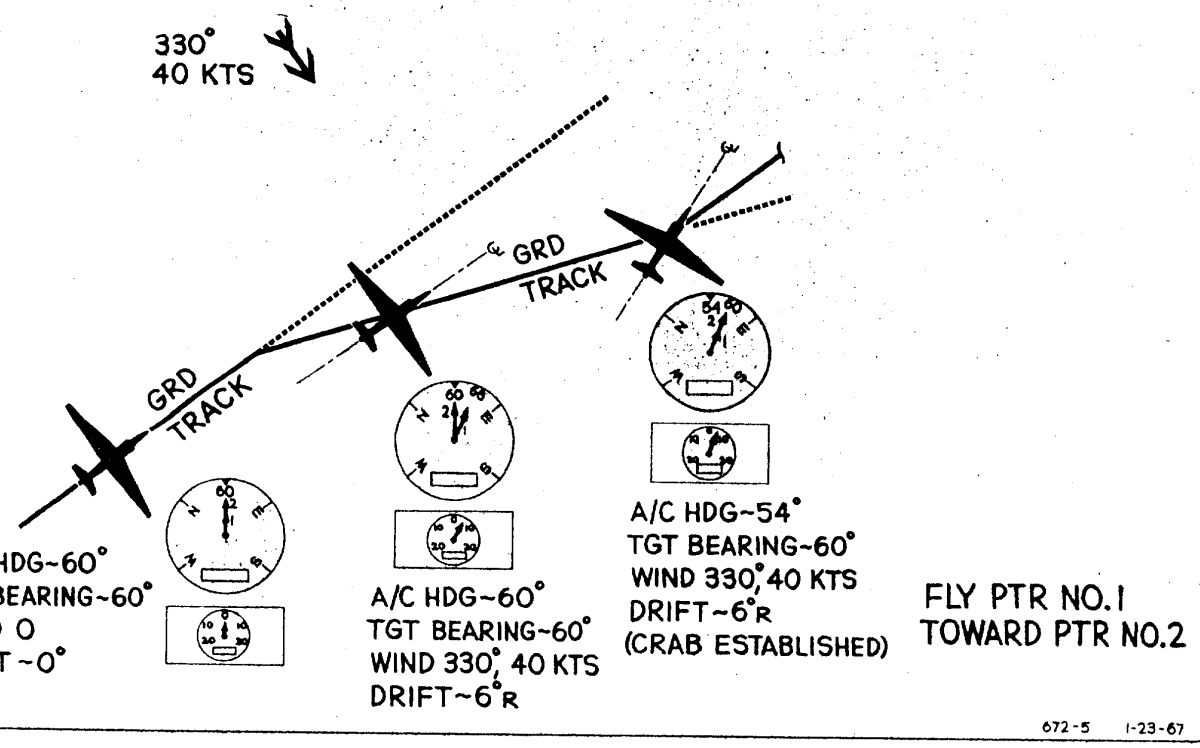


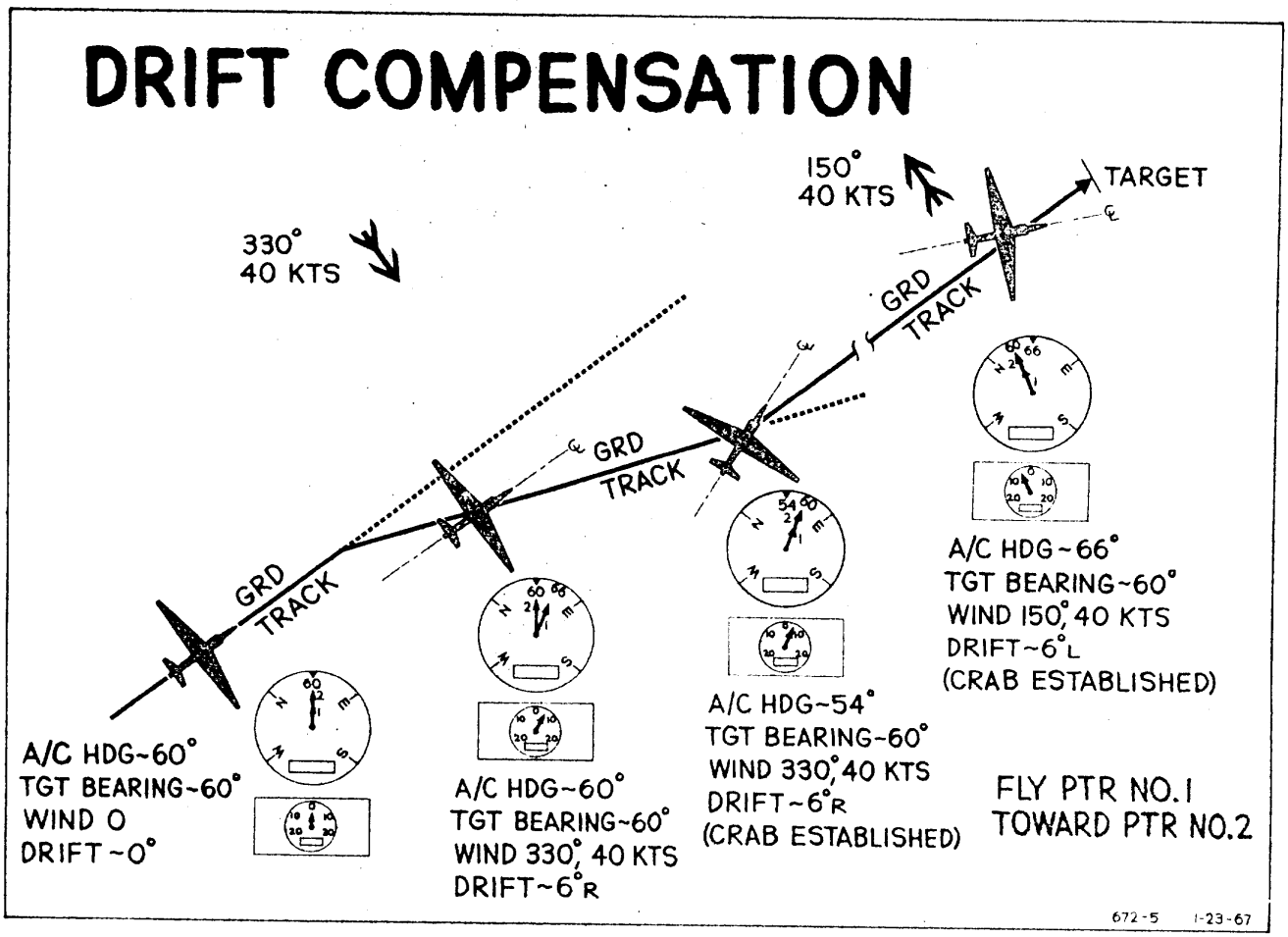




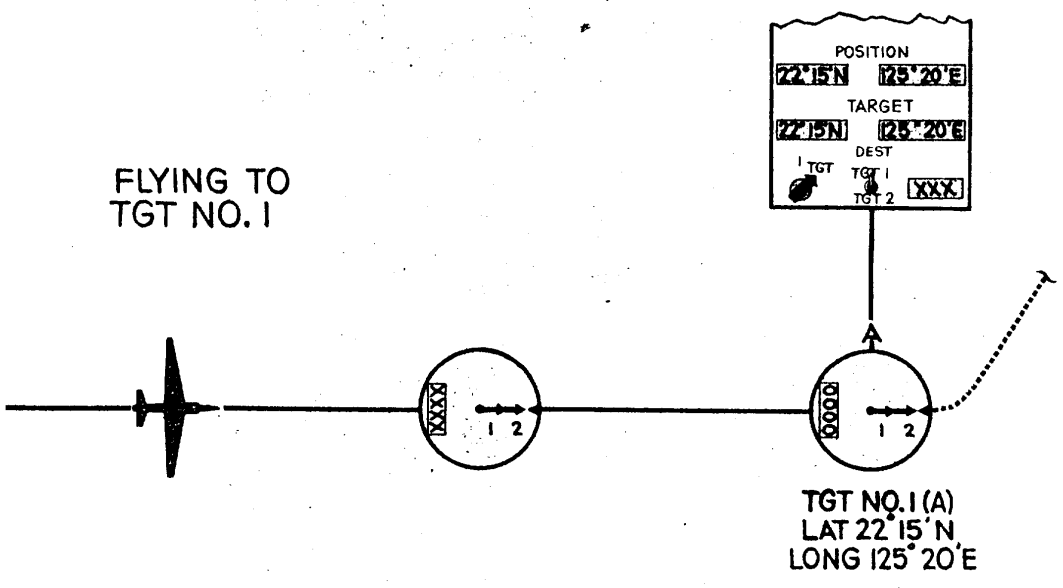


DRIFT COMPENSATION





TARGET ARRIVAL



672-21 1-23-67